

ORIGINAL ARTICLE

Trends in childhood injury mortality in Canada, 1979–2002

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Objective: To examine national trends in mortality rates for injuries among Canadian children younger than 15 years in 1979–2002.

Methods: Data on injury deaths were obtained from the Canadian Vital Statistics system at Statistics Canada. Injuries were classified using the codes for external cause of injury and poisoning (E-codes) by intent and by mechanism. Mortality rates were age adjusted to the 1990 world standard population. Negative binomial regression was used to estimate the secular trends.

Results: Annual mortality rates for total and unintentional injuries declined substantially (from 23.8 and 21.7 in 1979 to 7.2 and 5.8 in 2002, respectively), whereas suicide deaths among children aged 10–14 showed an increasing trend. All Canadian provinces and territories showed a decreasing trend in mortality rates of total injuries. Motor vehicle related injuries were the most common cause of injury deaths (accounted for an average of 36.4% of total injury deaths), followed by suffocation (14.3%), drowning (13.5%), and burning (11.1%); however, suffocation was the leading cause for infants. The number of potential years of life lost due to injury before age 75 decreased from 89 343 in 1979 to 27 948 in 2002 for children aged 0–14 years.

Conclusions: During the period 1979–2002, there were dramatic decreases in childhood mortality for total injuries and unintentional injuries as well as various degrees of reduction for all causes of injury except suffocation in children aged 10–14 years and drowning in infants. The reason for the reduction in injury mortality might be multifactorial.

Injuries are the leading cause of childhood death and a significant contributor to childhood morbidity, long term disability, and healthcare costs in most industrialized countries.^{1–3} Childhood injury has also been a serious public health problem over the past several decades in Canada. Similar to other countries, injuries are the leading cause of death for children over 1 year old.⁴ Each year in Canada, more children and youth over age 1 die from injuries than from all other causes. In 1997, there were 483 deaths due to injury, which accounted for 41.2% of all deaths among children aged 1–14 years.⁴ For every death due to injury across Canada, there are 45 hospitalizations and an estimated 1300 visits to emergency rooms, and more than 90% of these injuries are predictable and preventable.⁵

Detailed analysis of trends and changes in injury mortality over the years could facilitate program planning and evaluation, and help us to prioritize our control efforts.

We analyzed changes in childhood mortality rates attributable to injury and assessed the nationwide trends in total and cause-specific injury mortality among children aged 0–14 years in Canada during the period 1979–2002.

METHODS

Annual mortality data were obtained from the Canadian Vital Statistics system at Statistics Canada. The Vital Statistics system is a statutory, computer based register that covers the whole Canadian population. The death database includes data on demographic factors, date of death, underlying cause of death (classified according to the World Health Organization's International Statistical Classification of Diseases and Related Health Problems), and province or territory of occurrence of death.

Since the registration of deaths is a legal requirement in each Canadian province and territory, reporting is virtually complete. Undercoverage may occur because of late registration; for example, the number of cases by late registration for 1996 represents approximately 400 deaths, six years after the

year of death (accumulated late records), or 0.2% of the total records.⁶ Duplicate death registrations are identified as part of the regular processing operations on each provincial and territorial subset as well as by additional interprovincial checks.

The accuracy of the database is maximized by checking at the provincial or territorial level and at Statistics Canada's national level. The quality of the data capture and data coding is evaluated both annually and on an irregular basis in comprehensive studies.

Injuries were coded according to the International Classification of Disease, 9th Revision (ICD-9) (1979–1999) and 10th Revision (ICD-10) (2000–2002). These codes were used to group injuries by intent: unintentional, self-inflicted (suicide), assault, legal intervention/war, and undetermined, as well as by mechanism: cut/pierce, drowning, fire/hot object/substance (burning), firearm, machinery, transport including motor vehicle traffic (MVT), natural/environmental, poisoning, struck by/against, and suffocation, among others. Adverse effects due to drug and medical care, which are included in the external causes of injury and poisoning chapter of the ICD-9, were excluded from the injuries in this study.

In order to minimize the impact of change in coding system from ICD-9 to ICD-10 on the rate estimates, we made modification in grouping. For example, fracture unspecified was included in the category of fall in ICD-9 but is coded to X59 (exposure to unspecified factor) in ICD-10, therefore we excluded fracture unspecified from fall for the period of 1979 to 1999 to be compatible with ICD-10. We moved cases with ICD-9 codes E830 and E832 (drowning unintentional) to the category of water transport related injury; E924.1 and E961

Abbreviations: AAPC, average annual percent change; ASMR, age standardized mortality rate; ICD-9, International Classification of Diseases, 9th Revision; ICD-10, 10th Revision; MVT, motor vehicle traffic; PYLL, potential years of life lost.

(burning) moved to poisoning; E958.7 and E988.7 moved from scald due to hot object or substance to other specified/NEC; E958.6 and E988.6 (air crash) moved from other and unspecified transport (self-inflicted and undetermined) to other specified/NEC self-inflicted (X83) and undetermined (Y33); E846 moved from other specified classifiable to land transport, other (unintentional) because there is an equivalent in ICD-10 transport codes (V83); E847–E848 moved from other specified, classifiable to other and unspecified transport; E904.0 from natural/environmental, unintentional to other specified, classifiable, assault (neglect and abandonment, Y06). E958.3 and E988.3 moved from natural/environmental self-inflicted and undetermined to other specified/NEC, respectively; E958.4 and E988.4 moved from other specified, classifiable to other specified/NEC; E990 and E994 moved from other classifiable, legal intervention/war to burning, legal/war and to other and unspecified transport legal intervention/war, respectively.

Annual population estimates were taken from Statistics Canada's annual demographic statistics (available at <http://www.statcan.ca/Daily/English/050629/d050629d.htm>). The population estimate for infants under age 1 is a mid-year estimate and not the number of live births. To facilitate international comparison, all age adjusted rates were calculated using the direct method with reference to the 1990 world standard population for males and females combined.

Secular trends in childhood mortality rates for total injuries and cause specific injuries from 1979 to 2002 were estimated by Poisson and negative binomial regression models, using the annual standardized mortality rates for the specific age groups of interest as well as various intents or mechanisms. Deviance and Pearson χ^2 divided by the degree of freedom were used to detect overdispersion or underdispersion. As the above values were greater than 1 in the

Poisson regression modeling and were close to 1 in the negative binomial regression modeling, negative binomial regression models were used to estimate the secular trends. The average annual percent change (AAPC) was derived from the regression coefficients of these models during the described periods.

RESULTS

From 1979 to 2002, there were significant and substantial decreases in annual numbers of deaths and age standardized mortality rates (ASMRs, per 100 000 population) due to injury among all Canadian children aged 0–14 years, and within age subgroups (<1, 1–4, 5–9, and 10–14 years) (table 1). Infants aged less than 1 year consistently had the highest injury mortality rates of the age groups. Over the entire study period, the age standardized injury mortality decreased by 69.6% for children aged 0–14 years (from 23.8 in 1979 to 7.2 in 2002). The decreasing trend in injury mortality was seen in both boys and girls (data not shown).

The childhood mortality rates attributed to total injuries declined for all provinces and territories over the study period, and the rates were comparable across the Atlantic region, Ontario, Quebec, the Prairies and British Columbia, with higher rates in the Territories (data not shown).

When the annual (1979–2002) ASMRs due to injury were analyzed by intent, unintentional injuries accounted for an average of 86% of the total injury deaths, whereas intentional injuries (including suicide, assault, and legal intervention or war) and injuries of undetermined intent represented only a small proportion of the total injuries (table 2). In 1979, suicide, assault and undetermined injuries accounted for 1.5%, 5.8%, and 1.5% of total injury deaths respectively; in 2002, the corresponding percentages were 4.8%, 7.4%, and 2.1%. There was only one death from legal intervention or

Table 1 Annual deaths and age standardized mortality rate per 100 000 population due to injury, by age group, children aged 0–14 years, Canada, 1979–2002

Year	0–1		1–4		5–9		10–14		0–14	
	n	Rate	n	Rate	n	Rate	n	Rate	n	Rate
1979	147	41.1	372	26.2	373	20.4	425	20.9	1317	23.8
1980	132	36.1	343	24.0	318	17.5	360	18.3	1153	21.1
1981	128	34.8	335	23.3	289	16.1	367	19.0	1119	20.5
1982	75	20.3	280	19.3	219	12.2	330	17.3	904	16.4
1983	98	26.5	269	18.3	241	13.4	278	14.7	886	16.2
1984	91	24.6	275	18.6	235	13.0	260	14.0	861	15.8
1985	68	18.4	253	17.1	219	12.1	258	14.0	798	14.6
1986	81	22.0	262	17.8	205	11.2	223	12.3	771	14.3
1987	82	22.1	260	17.5	183	9.9	267	14.7	792	14.5
1988	65	17.6	217	14.5	190	10.1	236	12.9	708	12.8
1989	64	16.7	235	15.5	183	9.6	212	11.4	694	12.4
1990	68	16.9	225	14.7	188	9.8	242	12.9	723	12.7
1991	67	16.5	173	11.2	154	8.0	211	11.1	605	10.5
1992	56	13.9	194	12.2	179	9.2	189	9.8	618	10.6
1993	81	20.7	179	11.0	154	7.9	183	9.4	597	10.2
1994	61	15.8	194	11.9	133	6.8	200	10.1	588	10.0
1995	51	13.4	158	9.9	136	6.8	212	10.6	557	9.3
1996	44	11.6	147	9.3	151	7.5	153	7.6	495	8.4
1997	54	15.1	153	9.8	134	6.6	211	10.4	552	9.3
1998	44	12.7	135	8.8	117	5.7	185	9.1	481	8.2
1999	39	11.5	137	9.2	125	6.1	168	8.3	469	8.1
2000	57	16.8	91	6.3	90	4.4	182	8.9	420	7.2
2001	35	10.5	116	8.1	97	4.8	138	6.6	386	6.8
2002	49	15.0	103	7.3	91	4.6	171	8.1	414	7.2
Average	72		213		184		236		705	
AAPC		–4.63		–5.48		–5.87		–4.12		–5.05
Lower 95% CL		–5.69		–5.91		–6.40		–4.65		–5.40
Upper 95% CL		–3.57		–5.05		–5.34		–3.58		–4.70

Mortality rates are age adjusted to the 1990 world population.
AAPC, average annual percent change; CL, confidence limit.

Table 2 Annual deaths and age standardized mortality per 100 000 population due to injury, by intent, children aged 0–14 years, Canada, 1979–2002

Year	Unintentional		Self-inflicted		Assault		Legal intervention/ war		Undetermined	
	n	Rate	n	Rate	n	Rate	n	Rate	n	Rate
1979	1201	21.7	23	0.3	74	1.4	0	0.00	19	0.3
1980	1080	19.8	21	0.3	36	0.7	0	0.00	16	0.3
1981	1010	18.6	35	0.6	59	1.1	0	0.00	15	0.3
1982	819	14.9	28	0.4	41	0.8	0	0.00	16	0.3
1983	801	14.7	23	0.4	47	0.9	0	0.00	15	0.3
1984	757	13.9	28	0.5	59	1.1	0	0.00	17	0.3
1985	719	13.2	18	0.3	50	0.9	0	0.00	11	0.2
1986	668	12.4	25	0.4	59	1.1	0	0.00	19	0.4
1987	702	12.9	30	0.5	50	0.9	0	0.00	10	0.2
1988	632	11.4	28	0.5	35	0.7	0	0.00	13	0.2
1989	617	11.1	25	0.4	45	0.8	0	0.00	7	0.1
1990	636	11.2	30	0.5	45	0.8	0	0.00	12	0.2
1991	511	8.9	29	0.5	51	0.9	0	0.00	14	0.2
1992	529	9.1	34	0.5	45	0.8	0	0.00	10	0.2
1993	501	8.6	45	0.7	32	0.6	0	0.00	19	0.3
1994	481	8.2	49	0.7	45	0.8	0	0.00	13	0.2
1995	456	7.7	43	0.7	46	0.8	0	0.00	12	0.2
1996	393	6.7	41	0.6	52	0.9	0	0.00	9	0.2
1997	437	7.4	52	0.8	49	0.9	0	0.00	14	0.3
1998	372	6.3	46	0.7	47	0.9	1	0.02	15	0.3
1999	391	6.7	32	0.5	35	0.6	0	0.00	11	0.2
2000	326	5.6	46	0.7	35	0.7	0	0.00	13	0.2
2001	313	5.5	27	0.4	35	0.6	0	0.00	11	0.2
2002	334	5.8	35	0.5	37	0.7	0	0.00	8	0.2
Average	612		33		46		–		13	
AAPC		–5.78		2.29		–1.99		–		–
Lower 95% CL		–6.15		1.08		–3.00				
Upper 95% CL		–5.42		3.51		–0.98				

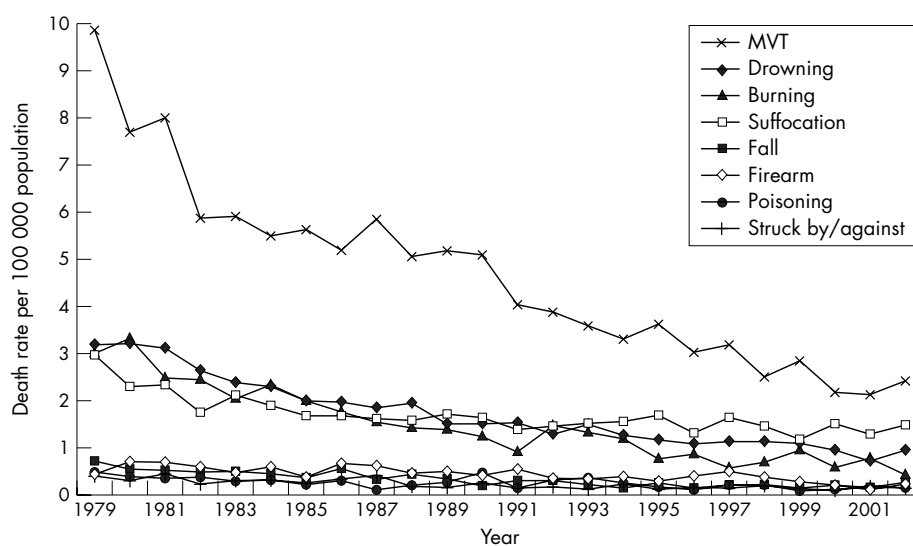
Mortality rates are age adjusted to the 1990 world population.
AAPC, average annual percent change; CL, confidence limit.

war during the entire study period. Although there was a significant decrease in unintentional injury mortality over the period, there was a small increase in suicide mortality. The declining trends in total injury deaths were mainly attributable to the decrease in unintentional injury deaths.

Unintentional injury deaths explained most of the marked decrease in total injury death rates in all childhood age groups (<1, 1–4, 5–9, and 10–14 years); nevertheless, deaths from suicide increased significantly among children aged 10–14 years, and deaths from assault and from injury of

undetermined intent did not change substantially for all age groups (data not shown).

We also examined the yearly childhood ASMRs due to injury by mechanism (cause) during the 1979–2002 period (fig 1). For children aged 0–14 years, MVT related injuries were the most common cause of injury death (average of 36.4% of total injury deaths), followed by suffocation (14.3%), drowning (13.5%), and burning (11.1%). Deaths due to falls, firearms, poisoning, or being struck by/against were less common. There was a decreasing trend in mortality

**Figure 1** Injury mortality for children (0–14 years) by cause, 1979–2002, Canada.

rates for all these causes of injury. Rates of mortality caused by MVT declined the most, from 9.9 in 1979 to 2.4 in 2002.

For infants aged less than 1 year, suffocation was the most common cause of injury death, followed by MVT and burning. For children aged 1–4 and 5–9 years, the most common cause was MVT, followed by drowning and burning; for children aged 10–14 years, MVT was still the most common cause, followed by suffocation and drowning (data not shown). Death rates for most of these causes of injury decreased by various degrees over the period for all age groups (<1, 1–4, 5–9, and 10–14 years); however, the rate of mortality from suffocation in children aged 10–14 increased significantly, mainly due to an increase in suicide by hanging, and death rate from drowning in infants did not change considerably (data not shown).

We also looked at the number of potential years of life lost (PYLL) due to injury before age 75, by year. For children aged 0–14 years, the PYLL were 89 343 in 1979 and 27 948 in 2002. The decreasing trend in PYLL for the study period applied to both sexes, but the decrease was more profound for boys than for girls (data not shown).

DISCUSSION

Our nationwide data showed that from 1979 to 2002, mortality due to total injuries and to unintentional injuries decreased substantially in all the age subgroups (<1, 1–4, 5–9, and 10–14 years), whereas death caused by suicide increased significantly among the oldest group (aged 10–14). For all children aged 1–14 years, MVT was the most common cause of injury death. For infants, however, suffocation was the most common cause of death and MVT ranked second. There was a decreasing trend in the mortality rate for all causes of injury, except for the increasing trend in mortality from suffocation for children aged 10–14 years and no considerable change in mortality from drowning in infants.

Our study results are similar to those reported by other Western countries regarding a significantly decreasing trend in mortality rates due to total and unintentional injuries among children aged 0–14 years.^{7–14} However, the mortality rates for total injuries in Canada were higher than those in Finland and declined more quickly: the death rates due to total injuries for Finnish children aged 0–14 years were 18.9 for boys and 7.5 for girls in 1979, while the corresponding rates were 7.1 and 2.8 in 2001 (decreased by 62.4% for boys and 62.7% for girls versus 73.1% and 68.7% in Canada for the same period).⁷ Compared with European childhood mortality rates for unintentional injury, the Canadian rates were similar to those in most European countries, but higher than those in Sweden, Italy, and Finland, and lower than those in Portugal and the US.^{9 10 12}

Although Canadian childhood mortality rates due to total and unintentional injuries have been declining significantly, suicide mortality in children aged 10–14 years has been increasing. The increases in suicide mortality and the proportion of suicide deaths over all injury deaths (because of the decrease in unintentional injuries), suggest that suicide is a growing problem among Canadian children aged 10–14 years during the study period. This situation is similar to that in Sweden¹² and the United States.¹⁵ Our analysis also indicates that the increase in suicide mortality among children aged 10–14 was mainly due to the increase in deaths from suffocation, which, in turn, was caused by suicidal hanging.

Our results showed that transportation related and MVT injuries were the leading cause of injury death in children aged 1–14 years during the whole study period. This finding is in accordance with data from the UK,¹³ the US,¹⁵ Europe,⁹ and New Zealand.¹⁶ Data from the World Health Organization

showed that, in 2000, traffic injuries ranked first in injury related causes of death among children of both sexes aged 5–14 years in high income countries, and ranked second in low and middle income countries.² Fortunately, our results also indicated dramatically decreasing trends in childhood mortality from transportation related and MVT injuries, which may be attributed to a combination of improving vehicle, roadway, and driver safety, and comprehensive preventive intervention strategies involving multisectors such as safety legislation and regulations enforced by federal, provincial, and municipal government as well as educational efforts and safety programs.^{17–19} Improved traffic safety and intensive promotion of child safety seats and seat belts as well as helmets are likely playing an important role.

We also found that drowning was another major cause of injury death in children aged 1–14 years, with the highest rate among those aged 1–4 years, and it was mainly (>95%) unintentional. A similar situation exists in Europe as a whole,⁹ in New Zealand,¹⁶ and in the US.²⁰ Drowning is a significant cause of childhood death in many parts of the world.²¹ It is estimated that almost half a million deaths were caused by drowning worldwide in 2000, and over half of them involved children aged less than 15 years.²² Drowning was the second leading cause of injury deaths, only exceeded by road traffic crash related deaths.³ As in other countries,^{23–25} the mortality rate from drowning in Canadian children has been declining over the past several decades. This could be attributable to multifaceted effective interventions, such as the installation of barrier or pool fencing as required by the Municipal bylaws and the practice of covering pools; more supervision of young children when they are in or around the water; more supervision and lifeguards at public swimming pools, rivers, or lakes; increased availability of patrolled swimming sites and pools; increased use of personal floatation devices when riding on a boat or playing near a river, lake, or ocean as required by Boating Practices/Regulations; and more educational programs that improve children's swimming ability and teach children never to swim alone or without adult supervision; as well as reduced exposure through restricted swimming or play in unsupervised settings and adopting more sedentary lifestyles.^{19–21 23} However, our study also showed that, despite significant declines in drowning deaths among age groups 1–4, 5–9, and 10–14 years, the mortality rate did not decrease among infants younger than 1 year old. This situation prompts searching for more effective and targeted preventive strategies.

We observed that suffocation was the most common cause of injury related death in infants aged less than 1 year. This finding agrees with other study results from the US,^{11 26} the UK,¹³ and New Zealand.¹⁶ Suffocation in infants is caused by the inhalation or ingestion of food or other objects that block respiration (obstructive suffocation) or by other mechanical means that hinder breathing, such as a plastic bag over the nose or mouth, suffocation by bedding, and unintentional or intentional hanging or strangulation (mechanical suffocation). In our study, 55 (65.5%) of the 84 infant deaths from suffocation in 1979 were classified as unintentional choking on food and gastric contents or other substance, three (3.6%) as unintentional suffocation by a plastic bag, 19 (22.6%) as unintentional suffocation in a bed or cradle, one (1.2%) as unintentional hanging in a bed or cradle, three (3.6%) as homicide, and three (3.6%) as intent undetermined. However, of the 23 deaths from suffocation in 2002, the corresponding numbers were 2, 0, 11, 0, 0, and 4. Some studies have found that infant deaths due to mechanical suffocation by beds, bedding, pillows, and plastic bags were increasing while the rate of obstructive suffocation was decreasing.^{11 26 27} One study suggested that the risk of

suffocation death was substantially higher for infants in adult beds compared with those in cribs.²⁸ Nevertheless, the infant death rate from suffocation in Canada has decreased significantly.

The considerable decrease in injury deaths in children suggests that most childhood injury deaths are preventable. The reasons behind the decline may be multifactorial. In addition to factors mentioned in previous paragraphs, other factors included educational campaigns, community safety programs, legislation and safety regulations, child resistant packaging for prescribed drugs, increased use of child safety seats and seat belts and helmets, improved road conditions, safer playgrounds (layout, equipment, and surfacing), comprehensive counselling in injury prevention for parents and caregivers, and increased use of residential smoke detectors^{19–29–38} as well as improvement and expansion of passive preventive measures, such as trauma centers, burn treatment centers, and regional poison control centers.³⁹ Another reason suggested for the decreasing trends is that fewer children are exposed to environmental specific risks, and thus at lower risk for injuries.¹⁴ The substantial decrease in Canadian hospitalization rates due to injury over the study period, along with days (and mean days) stayed in hospital (data not shown), suggests that better primary prevention and improvement in emergency acute care both contributed to the decrease in injury mortality in Canadian children. However, the higher mortality rate in the territories requires more targeted intervention in these areas.

To our knowledge, no nationwide study assessing recent data on childhood injury mortality in Canada has been published and this is the first study that examined the long term temporal trend of childhood injury mortality using the most recent available national data up to the year of 2002. This study used nationwide mortality data; therefore the results represented the real picture of injury burden in Canadian children. However, all Canadian provinces and territories began to adopt the ICD-9 for cause-specific coding in 1979, but they used the ICD-10 in 2000 for cause-specific coding of death. There are some differences between the two systems. The change might cause the rates increasing for some types of injury while decreasing for others. Although we made modification on the grouping of injuries, there might be some changes unaccounted. For example, secondary fires resulting from explosion are included in ICD-9 but excluded in ICD-10; choking on food and gastric contents included choking on regurgitated food in ICD-9 and in ICD-10 choking on gastric contents is a separate code (W78); ICD-10 excluded exposure to electric current but no mention of this exclusion is in ICD-9.

Because the registration of deaths in each province and territory is mandatory, missing data would be minimal. However, we could not rule out the possibility of misclassification (miscoding) of injuries by intent and cause. For example, some deaths of undetermined intent and unknown cause in infants could be the result of neglect or abandonment or abuse, thus should be grouped to assault.⁴⁰ But the degree of misclassification of injuries by intent and by cause is unknown.

Another limitation is the lack of information on location of injury leading to death in the death data before 1991. Availability of this information would be very helpful for more targeted intervention strategies.

IMPLICATIONS FOR PREVENTION

Canada has made significant progress in the prevention of childhood injuries. The dramatic decline in injury mortality in Canadian children reflected the effectiveness of various intervention programs. However, more targeted prevention efforts need to be adopted for reducing the injury mortality in

Key points

- During the 1979–2002 period, the mortality rates of total and unintentional injuries decreased substantially for both boys and girls, while suicide death among children aged 10–14 years increased.
- The childhood mortality rates of total injuries declined for all Canadian provinces and territories and the rates were comparable across the Atlantic region, Ontario, Quebec, the Prairies, and British Columbia, but with higher rates in the Territories.
- Motor vehicle traffic related injuries were the leading cause of injury death for children aged 1–14 years, as was suffocation for infants.
- There were various degrees of reduction in mortality from all causes of injury except suffocation in 10–14 year olds and drowning in infants.
- The decrease in child injury mortality might be attributed to multiple prevention strategies including governmental legislations and regulations, educational campaigns and community safety programs.
- This paper is an addition to the literature that describes the epidemiology of childhood injury in Canada, and demonstrates that Canada has been successful in reducing injury mortality in childhood.

the Territories. The fact of the flat mortality rates of drowning in infants over the study period may require more education programs and counselling for parents that the close and constant watch of infants when they are in or near water is required. Intervention strategies are urgently needed to tackle the increasing trend in self-inflicted injuries in children aged 10–14 years.

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LACUNAE

Virginia House of delegates clears bill limiting gun queries

The Virginia House of Delegates voted 88 to 11 in February to limit the questions that pediatricians can ask patients about firearms in their homes. The Bill would apply to doctors conducting routine screenings of patients for risks. The physicians would be prevented from asking about firearms if the information did not relate to a complaint made by the patient or to any other patient inquiry. The Bill was sponsored by delegate ward Armstrong, who is a member of the National Rifle Association. The Bill was opposed by Virginia Chapter of the American Academy of Pediatrics and the Medical Society of Virginia. The NRA supported the Bill because it will protect gun owners "from intrusive, unnecessary questions from medical professionals," according to the NRA Institute for Legislative Action website.